

# **FireStem User's Guide**

## **A stem heating tree mortality model**

Introduction: *FireStem* is a computer model designed to aid fire managers with predicting tree mortality based on fire behavior and intensity. The eventual goal is to link *FireStem* and *BahavePlus* to produce mortality predictions based on fuel loadings, moisture, and fire behavior for a given region and a range of species. To date, we have developed and validated *FireStem* for four species, Douglas Fir, Ponderosa Pine, Chestnut Oak, and Red Maple. Other species will be added as their thermophysical properties are identified and validated.

*FireStem* is based on fundamental thermodynamics and heat transfer taking into account the thermophysical properties of individual species in order to predict temperature at the living tissue or cambium. Eventually, the user will be able to input a range of species for a given ecosystem, run *FireStem* and review the mortality prediction for a range of diameters for each species. Below follows step by step instructions for running such a simulation for the four test species mentioned above.

### Instructions for running *FireStem*

Double click on the FireStem.exe icon to start the model.

Click on “**Options**”, then “**General Settings**” to view the general settings.

General settings include:

Measurement system: This gives the user the option to use either metric or US dimensions.

Number of diameters to step through: This allows the user to choose a range of up to 10 diameters to test. Note: the more diameters investigated the longer the computer takes to run a simulation. *We suggest a range between 4 and 6 initially.*

Run the compressed model: The compressed model runs faster but is less accurate due to less iterations in the model. *Depending on your computer speed, we recommend running the non-compressed version.*

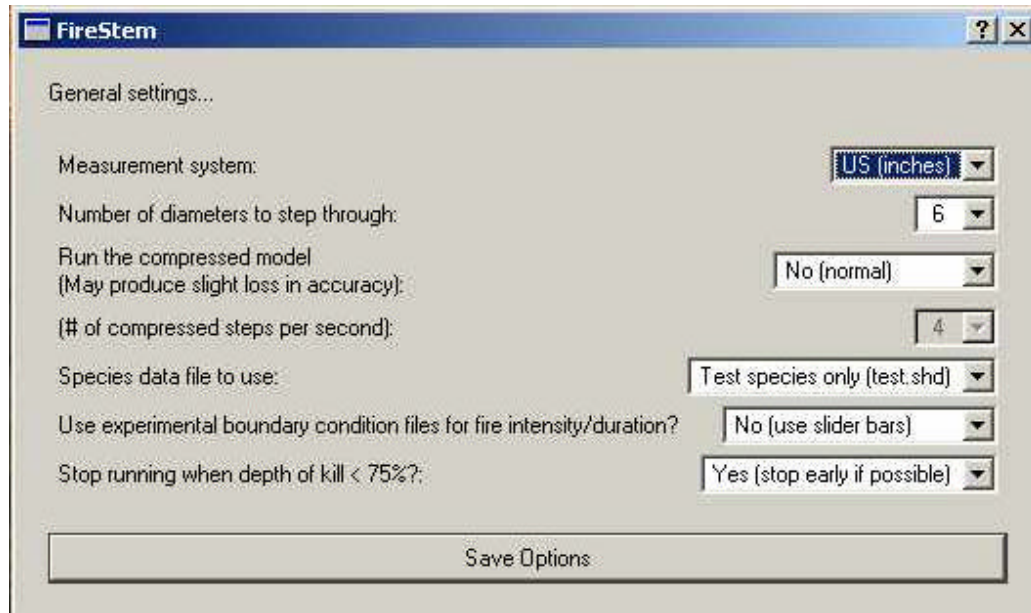
(# of compressed steps per second): When running the compressed version, the user can choose from 2 to 16 steps per second. Note: the fewer the steps per second the less accurate the results, but faster the simulation. *If you run the compressed version, start with a minimum of 8 steps per minute.*

Species data file to use: The user can choose from a “Test species” database which contains the four main species that were used to validate the model to date, or from the “All species” database which contains a sample of species from differing regions. The “All species” database is somewhat limited at the moment but will be expanded with time.

Use experimental boundary condition files for fire intensity/duration? The experimental boundary conditions were used to validate the model. It is recommended that the user always choose the “No (use slider bars)” option.

Stop running when depth of kill <75%: This option allows the user to exit the model calculations once a value for kill depth is less than 75% of the bark thickness for each size class, thus reducing the overall time to run a simulation. In other words, if the heat pulse only penetrates the outer 75% of the bark or less for a given diameter then the model exits at that point rather than continuing due to the fact that bark thickness only increases with size. *In order to increase the computation time we recommend selecting “Yes” on this option.*

A typical “General settings” page looks like this.....



Once the user has selected the desired settings, click “**Save Options**” to return to the main page.

Click on “**Options**”, then “**Graph options**” to view the general graph settings.

Graph options simply give the user the choice between extrapolating the X and Y axis or not.

Click “**Save Options**” to return to the main page.

Click “**Run**” the “**Run 1-Dimensional model**” to view the parameter input menu.

The menu includes dropdown boxes for inputs for tree species, minimum and maximum stem diameter, percent (%) moisture of the inner bark, and bark thickness. Below follows a brief description of each.

Species: Select the species of interest from the dropdown box.

Min dia: Type in the minimum diameter size class that you would like to investigate, or use the default value. *Depending on the units selected, we recommend that users choose a minimum diameter no smaller than 2 inches or 0.05 meters.*

Max dia: Type in the maximum diameter size class that you would like to investigate, or use the default value.

Moisture (%): This value is actually the percent moisture at the inner bark or the moisture associated with the living tissue. The value varies seasonally and is not easily achievable; therefore, default are provided and it is suggested that you user experiment with the different values to observe how the results vary in order to “bracket” mortality for a give scenario.

Bark thickness: Bark thickness is well defined for most tree species and is dependent upon tree diameter. These mathematical relationships are contained within the model; however, it is recognized that there can be some variability among species depending on site productivity. The dropdown box for Bark thickness gives the user the ability to account for this variability if it is known.

Once each menu box has been completed for a species the user is then prompted to do the same for the next species of interest, up to four species.

Next, click on the “**# of steps to run:**” box and select the number of diameters to step through, from 2 to 10, for each species. This value was previously established during in the **General settings** option described above, but it is conveniently placed here as well to make adjustment rather than go back into the **Options** setup.

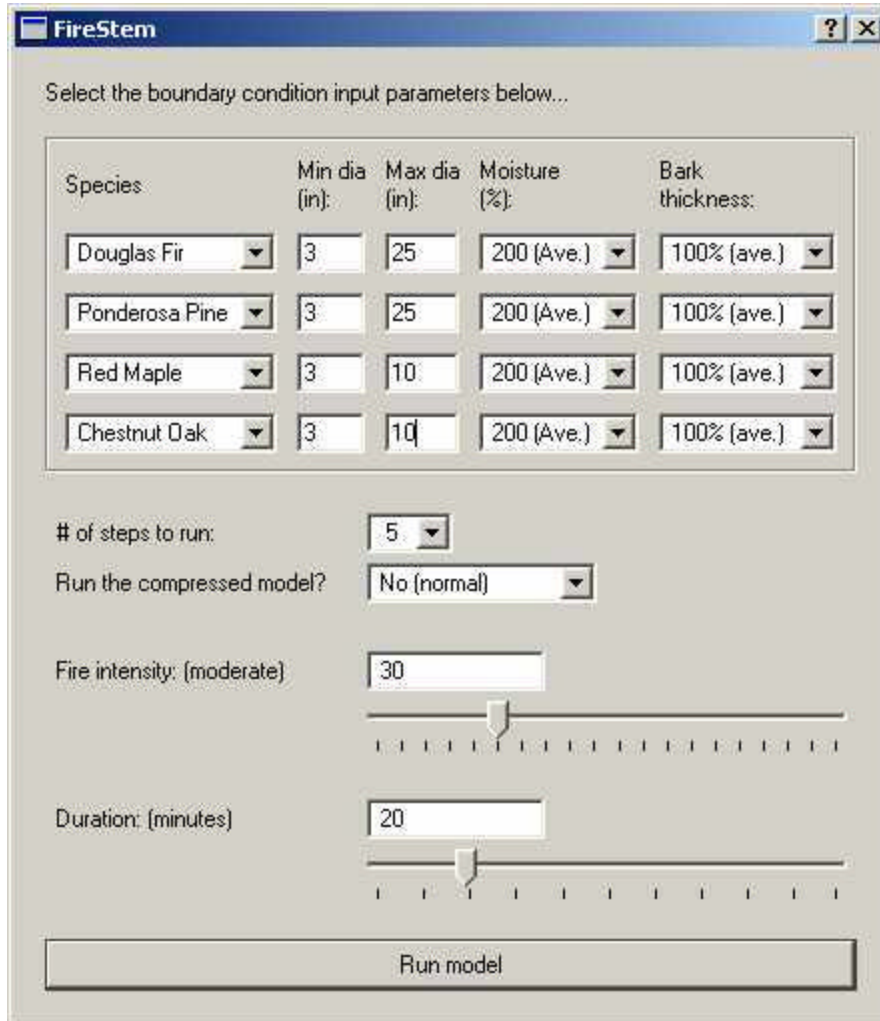
Next, the user is again given the option to run the compressed model.

The redundancy of the last two steps may become obvious after running the model for the first time. Depending on computation time, the user may wish to speed up the simulation by either evaluating fewer steps or running the compressed model.

Next, select the “**fire intensity**” by clicking on the slider bar. The value for fire intensity is energy per unit area ( $\text{kW/m}^2$ ), also known as heat flux, and is recognized in this case as the amount of energy released from the fire and received by the tree stems. It is this energy that is input into *FireStem* and used to calculate the cambium temperature for each species at each of the specified sizes classes. The range of fire intensity is from 5 (very low) to 100 (very high). An example of each would be a slow moving fire in needle cast with flame lengths between 6-12 inches verses a fast moving fire in heavy fuels with flame lengths ranging from 4-10 feet respectively.

Finally, select “**Duration: (minutes)**” from the slider bar. This value is simply the length of time that each size class is exposed to the above specified “**fire intensity**”.

A typical input page looks like this.....



The image shows a software window titled "FireStem" with a standard Windows-style title bar (minimize, maximize, close buttons). Below the title bar is a subtitle "Select the boundary condition input parameters below...". The main area contains a table for species parameters, followed by settings for the number of steps, model type, fire intensity, and duration, and a "Run model" button at the bottom.

Species	Min dia (in):	Max dia (in):	Moisture (%):	Bark thickness:
Douglas Fir	3	25	200 (Ave.)	100% (ave.)
Ponderosa Pine	3	25	200 (Ave.)	100% (ave.)
Red Maple	3	10	200 (Ave.)	100% (ave.)
Chestnut Oak	3	10	200 (Ave.)	100% (ave.)

# of steps to run: 5

Run the compressed model? No (normal)

Fire intensity: (moderate) 30

Duration: (minutes) 20

Run model

Once the setup is complete, click on "Run model".

A status bar will appear and give percent (%) completion along with the option to "cancel" the simulation.